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(54) Biodegradable, liquid-impervious sheet laminate

(57) Biodegradable sheet laminates are comprised of at least one liquid-impervious film of a biodegradable thermoplastic polymer and at least one layer of a fibrous substrate comprised of biodegradable fibers. The polymer may be cast, coated or sprayed onto the fibrous substrate.

Preferred biodegradable thermoplastic polymers are based on copolymers of hydroxycarboxylic acids. The fibers may be formed from a thermoplastic biodegradable polymer or be a cellulose or modified cellulose. The laminate may be used as the backsheet (16) of a disposable absorbent product such as a sanitary napkin or diaper together with a liquid pervious topsheet (12) and an absorbent structure between the topsheet and backsheet.

Fig. 1

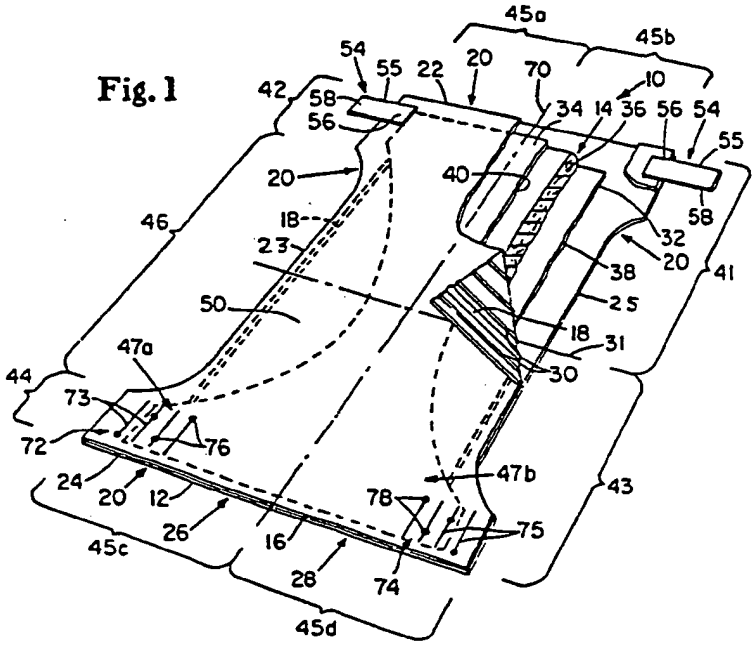

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Fig. 1

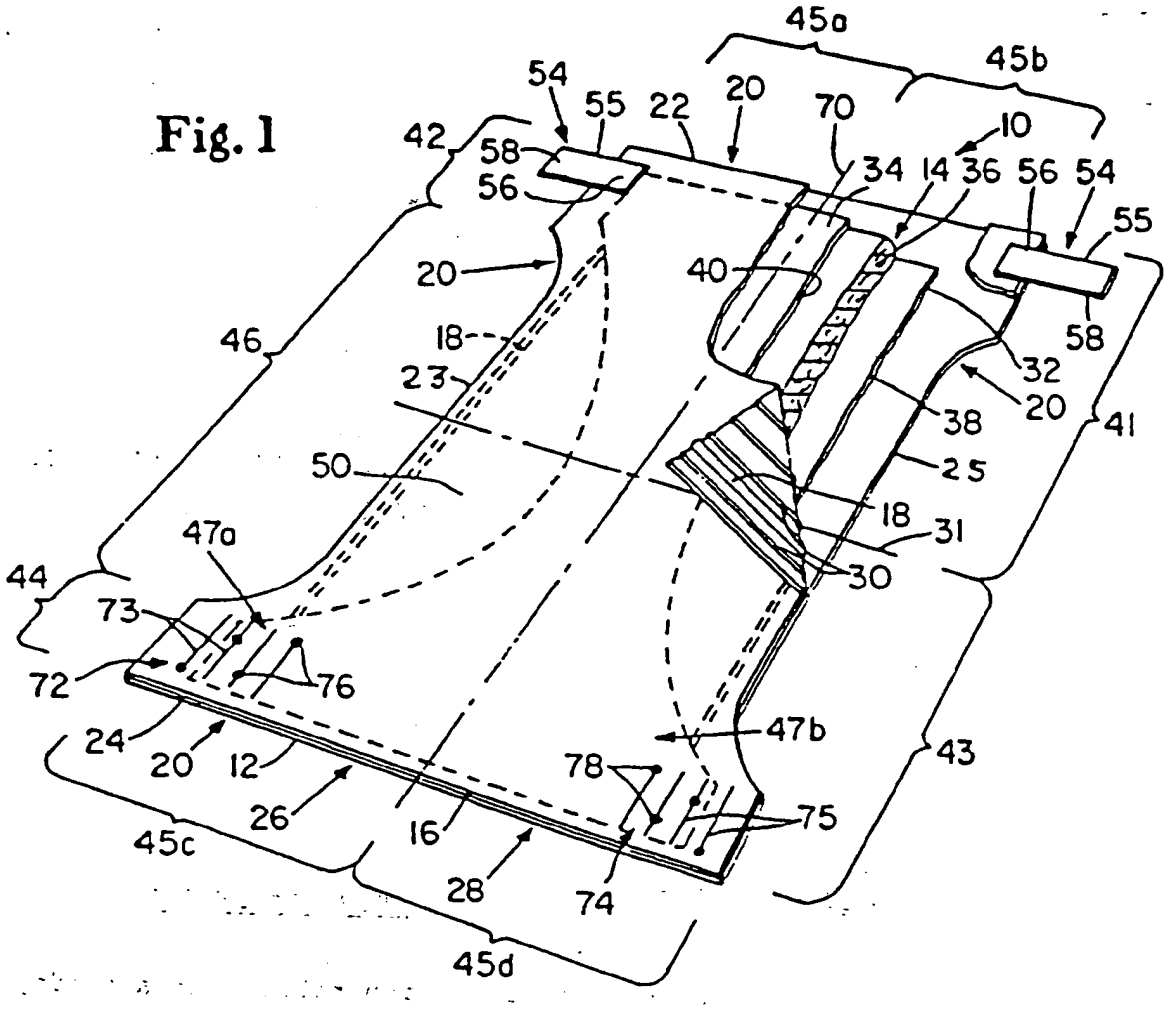
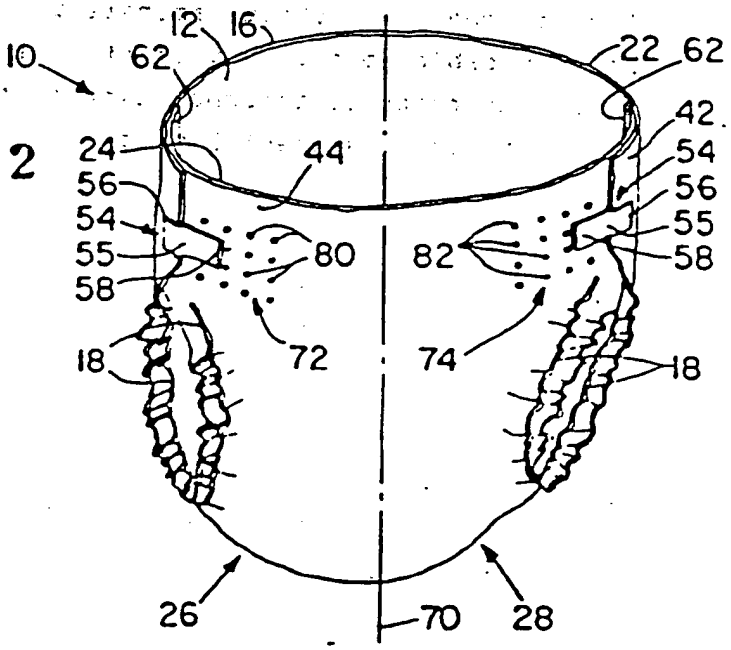


Fig. 2



BIODEGRADABLE, LIQUID-IMPERVIOUS SHEET LAMINATE

TECHNICAL FIELD

The present invention relates to a biodegradable, liquid-impervious sheet laminate which is suitable for use in disposable absorbent products, as well as to disposable absorbent products incorporating such a biodegradable liquid-impervious sheet laminate.

Disposable absorbent products, like diapers and catamenial products, typically are comprised of a liquid pervious topsheet, a liquid impervious backsheet and an absorbent structure which is disposed between said topsheet and said backsheet. This liquid-impervious backsheet typically consists of a thin film of polyethylene. The liquid-pervious topsheet typically is a nonwoven polyester, a polyolefin like polypropylene, but can also be rayon. The absorbent structure frequently comprises in major part airfelt which is a batt of woodpulp fibers, which may or may not be mixed with so-called absorbent polymers which are typically cross-linked polyacrylates starch materials that have been grafted with polyacrylates, or polymeric cellulose derivatives. In the case of disposable diapers, the absorbent structures are further provided with fastening tapes which comprise a pressure-sensitive adhesive against a backing which can be polyethylene or polypropylene but frequently is also a paper backing. In many cases there are also elastic strands provided along the leg openings of such diapers.

After use, an important portion of the disposable diaper, typically the topsheet and the absorbent structure, may be flushed down a domestic toilet. Frequently however the entire diaper is disposed of via domestic garbage. In any event, a polyethylene backsheet material does not lend itselfs to be flushed down a toilet, and will have to be disposed off by other means, typically domestic garbage. The several elements of a disposable diaper or other disposable structure are biodegradable to at least some extent, with the notable exceptions of the leg elastics, in some cases the fastening tapes, and in virtually all cases the liquid-impervious backsheet material. This means that in cases where domestic garbage is disposed of in landfills,

proliferated use of disposable absorbent structures, like disposable diapers, contribute significantly to a load of non-biodegradable material like polyethylene on the environment. It is therefore desirable to develop a fully biodegradable liquid-impervious sheet material that is suitable for use as the liquid-impervious backsheet in disposable absorbent structures. It is therefore an object of the present invention to provide biodegradable liquid-impervious sheet laminates that are suitable for such use. It is a further object of this invention to provide absorbent products that incorporate the biodegradable liquid-impervious sheet laminates of the present invention.

BACKGROUND OF THE INVENTION

Japanese 57210/002 (Lion, Fat and Oil KK), published June 16, 1981 discloses an absorbent product like a diaper or napkin comprising a leak preventive layer which can be a polyethylene laminated paper, a PVA film, sized paper, etc. This reference does not discuss the desirability of having a biodegradable backsheet, and in fact the polyethylene and the PVA film examples are not biodegradable. The sized paper of this reference is conceivably biodegradable but is propably not fully liquid-impervious.

U.S. Patent 3,658,062, issued March 9, 1972, Personal Products Company, discloses a disposable absorbent pad having a fluid impervious barrier film of collagenous material. A typical film material comprises collagen, plasticizer, water and cellulose. The plasticizer is preferably glycerine.

European Patent Application O 187 725 discloses a coated fabric comprising a base ply of a fiber material having a thermoplastic film bonded thereto. The base ply has densified and undensified portions thereof, and the thermoplastic film is heat-bonded to the base ply to at least the densified portions thereof.

U.S. Patent 4,275,105 discloses stabilized absorbent rayon webs. A thermoplastic web is melted into the rayon web to a controlled penetration web of from 10% to 40%. As a result, the cross-over points of the rayon fibers are effectively stabilized.

SUMMARY OF THE INVENTION

The present invention relates to a biodegradable, liquid-impervious, sheet laminate, suitable for use in disposable absorbent products and comprising :

a) at least one film of a biodegradable thermoplastic polymer; and

b) at least one layer of a fibrous substrate comprised of biodegradable fibers.

As the main function of the fibrous substrate is to impart strength to the laminate, preferred substrates have a tensile strength, at break, in the cross-machine direction of at least 4N. Suitable substrates are non-woven rayon fabrics having a basis weight of at least 15g/m^2 preferably from 19 to 40 g/m^2.

A preferred biodegradable thermoplastic polymer is a copolymer having a weight average molecular weight above 10.000 and containing repeat units

$$O.CH(CH_3)CH_2CO \qquad I$$

and repeat units

$$O{:}CR^1R^2(CR^3R^4)_nCO \qquad II$$

where n is 0 or an integer and R^1, R^2, R^3 and R^4 are each selected from hydrocarbon radicals : halo- and hydroxy-substituted hydrocarbon radicals; hydroxy radicals; halogen atoms; and hydrogen atoms, provided that, where n is 1 and R^2, R^3, and R^4 are each hydrogen atoms, R^1 is not methyl, said repeat units II constituting 0.1 to 50 mole % of the total repeat units in said copolymer. Preferred are copolymers wherein R^2, R^3 and R^4 are each hydrogen. More preferred are those copolymers that have a weight average molecular weight of at least 200,000. Most preferred are copolymers of trihydroxybutyrate and hydroxyvalerate having a trihydroxybutyrate/hydroxyvalerate weight ratio of from 98:2 to 70:30n and a weight average molecular weight of from 400,000 to 600,000.

Absorbent products incorporating the biodegradable liquid-impervious sheet laminate as a liquid-impervious backsheet are also part of this invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention provides a biodegradable liquid-impervious sheet laminate which is suitable for use as a backsheet material in disposable absorbent products. In view of the intended use, the sheet laminates of this invention have to be flexible, liquid-impervious, and have to possess sufficient strength and tear resistance. Biodegradable thermoplastic polymers have been disclosed in patent literature. These polymers can be formed into flexible films by well established techniques. The forming of such films is not a part of the present invention. Both for reasons of required flexibility and

for reasons of costs, the thermoplastic film has to b relatively thin if it is to be used in a backsheet of a disposable absorbent product. Typically, such films have a thickness of less than 60 micrometers; preferred are films having a thickness of from 15 to 30 micrometers.

Different from the well-known thermopolymers like polyethylene and polypropylene, the biodegradable polymers may not be formed into such thin films while maintaining the required strength and tear resistance. This is surprising as there is no inherent reason why biodegradable polymers would have inferior strength and tear resistance to polyolefins. This problem has now been solved by combining such a thin biodegradable thermoplastic polymer film into a sheet laminate with at least one layer of a fiber substrate comprised of biodegradable fibers.

A. The biodegradable thermoplastic polymer film

Any biodegradable thermoplastic polymer that can be formed into a liquid-impervious film can be used in the biodegradable sheet laminate of this invention. The term "liquid-impervious" connotes the ability to retain fluid under typical usage conditions of a disposable absorbent product when used in the backsheet of such a disposable absorbent product. In practical terms, this means that the material may be slightly watersoluble provided that the rate of the solution is sufficiently low that the film maintains its integrity during use. It also means that the film may be provided with tiny capillaries which permit breathing but are small enough so that they do not permit squeezing out of liquid. The term "biodegradable" as used herein means, in its broader sense, that the film material fully disintegrates upon contact with the environment (surface water, ground water, soil or sludge)

after a more or less prolonged period of time, for example up to twelve months. This term therefore includes materials that merely dissolve, like for example certain polyvinyl alcohols. Preferred herein are thermoplastic polymers that are biodegradable in a narrower sense of the word, i.e. materials which become at least 20% mineralized, within a period of up to 8 months. More preferred herein are materials that are converted to CO_2 and H_2O only, i.e. materials that do not contain nitrogen or sulfur. Particularly preferred are the high molecular weight copolymers containing trihydroxy butyrate residue and up to 50 more % of residues of other hydroxy acids, disclosed in U.S. Patent 4,477,654, issued October 16, 1984 to Holmes et al.

B. The fibrous substrate

For the purposes of the present invention, the fibrous substrate must be biodegradable, and must impart sufficient strength to the sheet laminate. Biodegradable fibers may be formed from a thermoplastic biodegradable polymer, the same or different as the one used for the film, by conventional spinning techniques. In an alternate embodiment, the fibers may be cellulose, like cotton fibers, or modified cellulose, like rayon fibers. The fibrous substrate may be woven or non-woven. Particularly preferred is a rayon non-woven substrate having a basis weight of at least 15 g/m^2, preferably from 19 to 40 g/m^2. The fibrous substrate must have a tensile strength, at break, in the cross-machine direction of at least 4N. Techniques for manufacturing woven or non-woven substrates of the required strength are well-known and do not form part of the present invention.

C. The sheet laminate

The sheet laminate may be formed in any one of a number of ways. For example, the film of thermoplastic biodegradable polymer may be cast, coated, or sprayed onto the fibrous substrate, either from the melt or from solution. In an alternate embodiment, a film of biodegradable thermoplastic material is formed using extrusion techniques, the film is then applied to the substrate and glued to the substrate, e.g. by using a biodegradable adhesive, or after softening the film with a suitable solvent like a low MW alcohol followed by calendering, or simply applying pressure (calendering) and optionally heat to the composite of film and substrate. If desired, several layers of either substrate or film or both can be used. For example, suitable laminates can be obtained comprising one layer of thermoplastic film sandwiched between two layers of substrate, or one layer of substrate sandwiched between two layers of film or alternating layers of film and substrate, etc. When two or more layers of substrate are used, it may be desirable to alternate machine direction and cross-machine direction, so as to obtain increased strength. However, for ease of manufacturing, it is preferred that all layers, both film and substrate, are applied in machine direction. Sufficient strength is obtained by a proper choice of the substrate, and of the number of layers used for particular purposes. For most applications in disposable absorbent products, a sheet laminate comprised of one layer of thermoplastic biodegradable film polymer and one layer of fibrous substrate is sufficient. For cost reasons this embodiment is preferred.

A particularly preferred embodiment of the present invention is a sheet laminate comprised of at least one layer of nonwoven rayon substrate and at least one layer

of film of a copolymer having a weight average molecular weight above 10,000, preferably above 200,000 and containing repeat units

$$O.CH(CH_3)CH_2CO \qquad I$$

and repeat units

$$O.CR^1R^2(CR^3R^4)_nCO \qquad II$$

where n is 0 or an integer and R^1, R^2, R^3, and R^4 are each selected from hydrocarbon radicals; halo- and hydroxy-substituted hydrocarbon radicals; hydroxy radicals; halogen atoms; and hydrogen atoms, provided that, where n is 1 and R^2, R^3, and R^4 are each hydrogen atoms, R^1 is not methyl, said repeat units II constituting 0.1 to 50 mole % of the total repeat units in said copolymer.

Preferred are polymers wherein R^2, R^3, and R^4 are each hydrogen. More preferred are polymers having a weight average molecular weight of at least 10,000, preferably at least 200,000, which are copolymers and contain at least 50 mol% of repeat units

$$O.CH(CH_3)CH_2CO$$

and being characterised by a triplet at 4.3 ppm as measured by proton nuclear magnetic resonance spectroscopy and peaks at 59.89 and 33.83 ppm (relative to a tetramethyl silane standard) measured by ^{13}C nuclear magnetic resonance spectroscopy.

Most preferred are copolymers of trihydroxybutyrate and hydroxyvalerate having a trihydroxybutyrate/hydroxyvalerate weight ratio of from 98:2 to 70:30, and a weight average molecular weight of from 400,000 to 600,000.

The above preferred biodegradable polymers will hereinafter be referred to as hydroxyacid copolymers. These hydroxyacid copolymers can be formed into laminates with rayon by simple heat-bonding techniques. For heat-bonding, a film of hydroxyacid copolymer is heat-softened at a temperature of from 120°C to 180°C, then combined with a sheet of nonwoven rayon material, and the ensemble is calendered at such a pressure that the loft of the non-woven is not destroyed. The laminate may also be formed immediately after casting of the biodegradable thermoplastic film, while the film is still hot. The resulting laminate is flexible, is liquid impervious, and has a high tensile strength at break.

Tensile Strength Test

An important parameter for liquid impervious sheet materials to be used in disposable absorbent products is the tensile strength. This is the force needed to obtain a specified elongation of the material. The tensile strength is typically measured at 5%, 10% elongation at break in both machine direction (MD) and cross machine direction (CD). For use in, e.g., sanitary napkins it is sufficient if the impervious sheet material has a tensile strength in cross machine direction at 10% elongation of 1N. Materials that are to be used in disposable baby diapers or adult incontinent pads should have a tensile strength (CD, at break) of at least 4N, preferably of at least 5N.

Suitable equipment for tensile strength testing is commercially available. Examples include Instron 1101-TM, 1102-TMS, 1122 or 1130, available from Instron Engineering Corp., Canton, Mass., and Thwing-Albert Q.C., or Intellect 500, available from Thwing-Albert Instrument Co., 10960 Dutton Rd., Philadelphia, Pa., 19154.

Samples of tensile testing are conditioned at 73°F ± 2°F (22.78 ± 1.1°C) and 50 ± 2% relative humidity for at least 2 hours prior to testing.
For tensile testing in CD, strips are cut of 1 inch (2.54cm) x 8 in (20.32cm) with the 8 in dimension parallel to cross machine direction. Similar strips are cut of MD tensile testing, except that the 8 in dimension is parallel to MD.

Example

A rayon nonwoven (from Pelytex, Wahlstedt/Holst, West-Germany) comprised of viscose fibers (1.7 dtex, 50mm), impregnated with a formaldehyde-free elastomer type binder at 16-20% by weight, is heat-bonded with a cast film of hydroxyacid copolymer. The heat-bonding is carried out at the temperatures exemplified hereinabove. Calendering of the laminate is carried out a moderate pressure such as to avoid too much penetration of the polymer into the rayon nonwoven, and to avoid destruction of the loft of the nonwoven. Biodegradable copolymers of trihydroxybutyrate and hydroxyvalerate are formed as described in U.S. Patent 4,477,654. The polymer resins are cast into films on laboratory film casting equipment; casting conditions are as follows

Polymer	I	II	III
trihydroxybutyrate (%)	93.5	87.5	81.0
hydroxyvalerate (%)	6.5	12.5	19.0
temp. first roll (°C)	170	165	160
temp. 2nd roll (°C)	170	165	160
temp. 3rd roll (°C)	175	170	165
temp. die (°C)	170	165	160

The same resins are processed on plant-scale film casting equipment. The temperatures are adjusted downward by 5 to 10°C so as to compensate for the heat resulting from the working of the resin which is greater than on laboratory equipment.
After casting, the films are chilled to 50-60°C, and kept at this temperature for 10 to 30 seconds to obtain crystallization of the polymer. Optionally, about 1% of a nucleation agent is added to the polymer.

Alternate films are cast, containing as plasticizers, Plasthall 7050 (8.5%) and Santicizer 8 (8.5%). Processing temperatures are adjusted downwardly due to the greater softness.

A first film of hydroxyacid copolymer has a thickness of 20-24 micrometers 25 to 30 g/m^2.

Of the laminates formed, tensile strength tests are performed both in MD and CD.

Laminate I — Rayon : 20 g/m^2 (NONWOVA 20/VI, from Pelytex, Wahlstedt/Holst, West-Germany)
Hydroxyacid copolymer film : 20-24 micrometers (25 to 30 g/m^2)

Tensile strengths (in N)

	Rayon only	Laminate
MD		
5% elong.	20.40	38.07
10% elong.	28.62	(break)
at break	37.05	44.62

	Rayon only	Laminat
CD		
5% elong.	0.73	2.86
10% elong.	1.52	3.99
at break	3.96	5.46

Laminate II — Rayon : 35 g/m^2 FINNWEBB from Finnwad Ltd (Finland) - (KA-4/4000)
Hydroxyacid copolymer film :
24-28 micrometers (30 to 35 g/m^2)

Tensile strengths (in N)

	Rayon only	Laminate
MD		
at 5% elong.	-	45.43
at 10% elong.	44.2C	57.27
at break	48.73	63.43
CD		
at 5% elong.	-	3.45
at 10% elong.	6.43	6.25
at break	10.01	9.65

Laminate III — Rayon : 30 g/m^2 FINNWEBB from Finnwad - Ltd (Finland)-(KA-4/3200)
Hydroxyacid copolymer film :
24-28 micrometers (30 to 35 g/m^2)

tensile strengths (in N)

	Rayon only	Laminate
MD		
at 5% elong.	-	35.67
at 10% elong.	40.80	42.73
at break	48.53	60.10
CD		
at 5% elong.	-	4.07
at 10% elong.	5.04	5.85
at break	9.18	9.56

Industrial Application

The biodegradable, liquid-impervious sheet laminates of the present invention are suitable for use in disposable absorbent products. Examples of such products are sanitary napkins, disposable baby diapers, and adult incontinent products. Typically, disposable absorbent products comprise a sheet of a liquid-impervious material, frequently referred to as the backsheet. Laminates of the present invention can be used to replace the conventional backsheet materials, typically polyethylene or polypropylene, as are used in disposable absorbent products.

In addition to being biodegradable, the laminates of the present invention offer the possibility of having at least one face presenting the cloth-like appearance of the fibrous substrate. In preferred embodiments of disposable absorbent products, the laminate presents the fibrous substrate on at least one face. This face is made the outer face of the absorbent product.

The use of the biodegradable liquid-impervious sheet laminate in disposable absorbent products is exemplified further in the following description of a preferred embodiment of a disposable diaper intended to be worn by an infant.

Brief Description of the Drawings

Figure 1 is a partially cutaway perspective view of a disposable diaper incorporating the present invention.

Figure 2 is a frontal view showing a disposable diaper incorporating the present invention, wherein the diaper is in a configuration which it would assume when fitted to a wearer.

Description of Preferred Embodiments

Referring now to the drawings, there is shown a preferred embodiment of the present invention as it would be used in a disposable diaper intended to be worn by an infant. As used herein, the term "disposable diaper" refers to a garment generally worn by infants or incontinent persons, which is drawn up between the legs and fastened about the waist of the wearer and further, which is intended to be discarded after a single use (i.e., it is not intend d to be laundered or otherwise restored and reused).

Figure 1 is a partially cut away perspective view of the disposable diaper 10 of the present inv ntion prior to its being folded and placed on the diaper wearer by the diaper user. As can be seen in Figure 1, a preferred diaper 10 basically comprises a liquid impermeable topsheet 12, an absorbent means 14, a liquid impermeable backsheet 16 and elastic member 18. While the topsheet 12, absorbent means 14, liquid impermeable backsheet 16, and elastic member 18 may be assembled in a variety of well known configurations, a preferred disposable diaper configuration is described generally in U.S. Patent 3.860.003 entitled "Contractable Side Portions for Disposable Diaper", which issued to K.B. Buell on January 14, 1975, and which patent is incorporated herein by reference.

Figures 1 and 2 show a preferred embodiment of the diaper 10 in which the topsheet 12 and the backsheet 16 are coextensive and have length and width dimensions generally larger than those of the absorbent means 14. The topsheet 16 thereby forming a periphery or, in other words, the outer extent of the diaper 10. The periphery 20 comprises first end 22, second end 24, first longitudinal edge 23, and second longitudinal edge 25.

The topsheet 12 may be affixed to the backsheet 16 in any suitable manner as is well known in the diaper manufacturing art. In a preferred embodiment, a multiplicity of longitudinal adhesive bands 30 of hot-melt adhesive are applied along the full length of the backsheet 16 generally parallel to the longitudinal centerline 70 of the backsheet 16. The longitudinal adhesive bands 30 serve to affix the topsheet 12 to the backsheet 16 at those points where these three components come together. The extent and location of the points where the topsheet 12, backsheet 16, and longitudinal adhesive bands 30 come together will depend on the spacing

between the longitudinal adhesive bands 30 and on the distance the topsheet 12 and the backsheet 16 extend beyond the absorbent means 14. The number of longitudinal adhesive bands 30 and the spacing therebetween should be sufficient to securely bond the topsheet 12 to the backsheet 16 in the area between the periphery 20 and the edge of the absorbent means 14.

A hot-melt adhesive suitable for use as longitudinal adhesive bands 30 is manufactured by Eastman Chemical Products Company, of Kingsport, Tennessee and marketed under the tradename Eastobond A-3. It will be noted that the above described manner of affixing the topsheet 12 to the backsheet 16 causes the topsheet 12 to be affixed to the backsheet 16 intermittently along the first and second ends, 22 and 24. The absorbent means 14 is thereby encased between the topsheet 12 and the backsheet 16. Of course, many alternative methods of affixing the topsheet 12 to the backsheet 16 may be used with satisfactory results. For example, the topsheet 12 may be affixed to the backsheet 16 indirectly rather than directly as shown in Figure 1. Thus, an intermediate member may be used to affix the topsheet 12 to the backsheet 16.

The diaper 10 has a first region 41 and a second region 43 divided by a latitudinal centerline 31. The diaper 10 also has a crotch portion 46 which coextends with part of the first region 41 and the second region 43, and which comprises that portion of the diaper 10 which, when worn, is positioned between the legs of the wearer. A longitudinal centerline 70 divides the diaper 10 into a first longitudinal side 26 and a second longitudinal side 28. The first and second regions 41 and 43 are also provided with first and second laterally spaced portions 45a and 45b which comprise portions of the first and second longitudinal sides 26 and 28.

The absorb nt means 14 may be any means which is generally compressible, conformable, non-irritating to the wearer's skin, and which is capable of absorbing and retaining liquids. A preferred absorbent means 14 has first and second opposed faces 32 and 34, respectively, and comprises an absorbent layer 36 and first and second tissue layers 38 and 40, respectively. The first and second tissue layers 38 and 40 overlay the major surfaces of the absorbent layer 36 to form the first and second opposed faces 32 and 34 of the absorbent means 14.

The absorbent layer 36 is intended to absorb and contain liquid and may be manufactured in a wide variety of sizes and shapes (e.g., rectangular, hourglass, etc.) and from a wide variety of liquid absorbent materials commonly used in disposable diapers, such as comminuted wood pulp which is generally referred to as airfelt. Other liquid absorbing materials may also be used in the manufacture of the absorbent layer 36 such as a multiplicity of plies of creped cellulose wadding, absorbent foams or sponges, polymeric gelling materials, like cross-linked polyacrylates, or any equivalent material or combination of materials. For increased integrity of absorbent layer 36, biodegradable thermoplastic fibers may be blended in with the absorbent material. The fibers are thermobonded for strength. The total absorbent capacity of the absorbent layer 36 should, however, be compatible with the design liquid loading in the intended use of the disposable diaper 10. Further, the size and absorbent capacity of the absorbent layer 36 may be varied to accommodate wearers ranging from infants through adults.

The preferred embodiment of diaper 10 illustrated in Figures 1 and 2 has an hourglass shaped absorbent layer

36, and is intended to be worn by infants ranging in weight from about 12 to about 26 pounds (about 5 kgs. to about 12 kgs.) The absorbent layer 36 is, therefore, a batt of airfelt approximately 16 inches (41 cm) long when measured along the longitudinal centerline, approximately 12 inches (32 cm) across the first and second ends 22 and 24, and approximately 4 inches (10 cm) across the narrowest part of the crotch portion 46. The absorptive capacity of the airfelt used for the absorbent layer 36 is sufficient to absorb and retain from about 8 to about 16 grams of water per gram of absorbent material. Accordingly, the airfelt used in the preferred embodiment shown in Figures 1 and 2 weighs from about 30 to about 56 grams and has a generally uniform caliper. It should be understood, however, that the size, shape, configuration, and total absorbent capacity of the absorbent layer 36 may be varied to accommodate wearers ranging from infants through adults. Therefore, the dimensions, shape, and configuration of the absorbent layer 36 may be varied (e.g. the absorbent layer 36 may have a varying caliper, or a hydrophilic gradient, or may contain polymeric gelling agents).

The first and second tissue layers, 38 and 40, are intended to improve the tensile strength of the absorbent core 14 and to reduce the tendency of the absorbent layer 36 to split, lump or ball when wetted. The first and second tissue layers, 38 and 40, also help to improve lateral wicking of liquids, thereby providing a more even distribution of liquid in the absorbent layer 36. While a number of materials and manufacturing techniques may be used to manufacture the first and second tissue layers, 34 and 40, satisfactory results have been obtained with sheets of tissue paper having a basis weight of approximately 10 pounds per 3000 square feet (16 gms per square meter) and having an air permeability of approximately 100 cubic feet per minute per square foot

(30 cubic meters per minute per square met r) over a 0.5 inch (13 mm) water pressure drop. While the first and second tissue layers, 38 and 40, are preferably coterminous with the absorbent layer 36, they may have different dimensions, a different configuration, or they may be omitted entirely.

The absorbent means 14 is superimposed on the backsheet 16 and is preferably affixed thereto by any means as is well known in the diaper art. For example, the absorbent core 14 may be secured to the backsheet 16 by a uniform continuous layer of adhesive, a patterned layer of adhesive, or an array of lines or spots of adhesive. In the preferred embodiment illustrated in Figures 1 and 2 the longitudinal adhesive bands 30 are used to affix the absorbent core 14 to the backsheet 16.

In prior art diapers, backsheet 16 is a film of polyethylene having a thickness of from about 0.012 mm to about 0.051 mm. In the diaper of the present invention, however, a biodegradable, liquid-impervious sheet laminate replaces this film of polyethylene. Preferably, the laminate has a tensile strength, at break, in cross machine direction of at least 4N, more preferably of at least 5N. Laminate I disclosed hereinabove is particularly suitable for this purpose. Preferably, the external face of the backsheet, i.e., the face shown in Figs. 1 and 2, is the rayon-substrate.

The backsheet 16 is impermeable to liquids and prevents liquids absorbed by the absorbent means 14 from wetting the undergarments, clothing, bedding, and other objects which contact the wearer of the disposable diaper 10.

In a preferred embodiment, the backsheet 16 has a

modified hourglass shape extending beyond the absorbent layer 36 a minimum distance of at least from about 0.5 to about 1.0 inch (about 1.3 cm to about 2.5 cm) around the entire diaper periphery 20. The marginal portion 48 is that portion of the diaper 10 between the diaper periphery 20 and the edge of the absorbent layer 36 and comprises longitudinal marginal portions 50 adjecent first and second longitudinal edges 26 and 28, respectively, in the crotch portion 46.

The topsheet 12 is compliant, soft feeling, and non-irritating to the wearer's skin and prevents the wearer of the diaper 10 from contacting the absorbent core 14. Further, the topsheet 12 is liquid permeable permitting liquids to readily penetrate through its thickness. A suitable topsheet 12 may be manufactured from a wide range of materials, such as natural fibers (e.g., wood or cotton fibers), synthetic fibers (e.g., polyester, polypropylene, but preferably of a biodegradable polymer), or a combination thereof. Alternatively, the topsheet 12 may be a foam, such as the reticulated foams which are well known in the art or any of the formed films which are also well known in the art. Preferably, the topsheet 12 is biodegradable.

Clearly there are a number of manufacturing techniques which may be used to manufacture the topsheet 12. For example, the topsheet 12 may be woven, nonwoven, spunbonded, carded, or the like. A preferred topsheet 12 is carded, and thermally bonded by means well known to those skilled in the nonwoven fabrics art. Preferably the topsheet 12 has a weight of from about 18 to about 25 grams per square yard, a minimum dry tensile strength of at least about 400 grams per centimeter in the machine direction and a wet tensile strength of at least about 55 grams per centimeter in the cross machine direction.

The elastic members 18 are affixed to the diaper 10 along both longitudinal marginal portions 50 so that they tend to draw and hold the diaper 10 against the legs of the wearer. Thus, when worn the diaper 10 will have elasticized leg openings. While this result may be accomplished by any of several means as are well known in the diaper art, a particularly preferred diaper construction incorporating elastic strips is described in detail in the hereinbefore referenced U.S. Patent 3,860,003. In addition, a method and apparatus suitable for manufacturing a disposable diaper having elastic leg bands are described in U.S. Patent 4,081,301 entitled "Method and Apparatus for Continuously Attaching Discrete, Stretched Elastic Strands to Predetermined Isolated Portions of Disposable Absorbent Products", which issued to K.B. Buell on March 28, 1978 and which patent is incorporated herein by reference.

Relating the teachings of U.S. Patent 3,860,003 to the preferred embodiment shown in Figures 1 and 2, it can be seen that elastic members 18 are operatively associated with both longitudinal marginal portions 50 in the crotch portion 46 in an elastically contractible condition so that in a normally unrestrained configuration the elastic members 18 effectively contract or gather the longitudinal marginal portions 50.

As used herein the term "operatively associated with" refers to two or more components which act together. In the preferred embodiment shown in Figures 1 and 2, the elastic members 18 are operatively associated with both longitudinal marginal portions 50 in the crotch portion 46. Thus, the elastic members 18 are affixed to the longitudinal marginal portions 50 so as to cause the longitudinal marginal portions 50 in the crotch portion 46 to be contracted or gathered.

In the preferred embodiment illustrated the elastic members 18 are affixed to a portion of the backsheet 16 in the longitudinal marginal portions 50. A suitable adhesive will be flexible and of sufficient adhesiveness to hold the elastic member 18 to the backsheet 16 while the elastic member 18 is streched. An adhesive which has been used with satisfactory results is manufactured by Century Adhesives Corporation of Columbus, Ohio and is marketed under the tradename Century 5227.

The elastic members 18 can be operatively associated with the longitudinal marginal portions 50 in an elastically contractible condition in at least two ways. For example, the elastic member 18 may be stretched and while in the stretched condition affixed to the uncontracted and unstretched longitudinal marginal portions 50. Alternatively, the longitudinal marginal portions 50 may be contracted (e.g., by pleating) and then affixing the unstretched elastic member 18 to the contracted longitudinal marginal portions 50.

A suitable elastic member 18 may be manufactured from a wide variety of elastic materials such as natural rubber, or elastomeric films such as krayton, ethylene propylene monomer, and polyurethane.

In addition, the elastic member 18 may take a multitude of configurations. For example, the width of the elastic members 18 may be varied from about 0.0015 inches to 1.0 inches or more; the elastic member 18 may comprise a single strip of elastic material or may comprise several parallel or non parallel strips of elastic material; or the elastic member 18 may be rectilinear or curvilinear. Still further, the elastic member 18 may be affixed to the diaper 10 in any of several ways which are well known in the art. For example, the elastic members 18 may be ultrasonically

bonded or heat sealed into the diaper using a variety of bonding patterns or the elastic members 18 may simply be glued to the diaper 10.

One material which has been found to work well as an elastic member 18 is an elastic tape having a cross section of 0.007 inches by 0.25 inches and which is manufactured from natural rubber. Such a product is marketed by Easthampton Rubber Thread Company under the tradename L-1900 rubber compound. The preferred elastic member 18 produces a tensile force of about 100 grams when stretched 100 percent from its relaxed condition.

The diaper 10 is provided with a fastening means 54 for maintaining the first and second regions 41 and 43 in an overlapping configuration when the diaper 10 is worn. Thus, the diaper 10 is fitted to the wearer and a closure around the waist of the wearer is formed utilizing the fastening means. In a preferred embodiment, the first laterally spaced portion 45a of the first region 41 is fastened to the second region 43 at a first attachment area 47a, and the second region 43 at a second attachment area 47b.

In a preferred diaper configuration, as in Figure 1 and 2, the diaper 10 has first and second waist regions 42 and 44 extending, respectively, from the first end 22 and the second end 24 of the diaper periphery 20 toward the lateral centerline 31 of the diaper 10 a distance from about 1/4 to about 1/3 the length of the diaper. Thus, the first waist region 42 is a part of the first region, and further encompasses portions of the first and second laterally spaced portions 45a and 45b of the first region 41. Correspondingly, the second waist region 44 is a part of the second region 43 and furth r encompasses portions of the first and second laterally spaced portions 45c and

45d of the second region 43. Preferably, the second waist region 44 is utilized as the attachment areas 47a and 47b. Thus, the fastening means 54 affixes the first and second laterally spaced portions 45a and 45b of the waist region 42 first region 41 to the first and second attachment areas 47a and 47b located at the second waist region 44 of the second region 43.

The fastening means 54 must be affixed to the first region 41 and the second region 43 in a manner and with a strength that is sufficient to resist the forces acting to cause the first and second regions 41 and 43 to separate during wearing.

The fastening means 54 may comprise any of the well known means for achieving a waist closure wherein discrete fastener means are utilized on each side of the centerline. Such fastener means include hook and pile fasteners and adhesive tape. A preferred fastening means 54 is the adhesive tape 55 as is well known in the diaper art.

When adhesive tape is used as the fastening means, it is desirable to provide a dedicated fastening surface in the frontal waist region of the diaper. This is particularly desirable if the outer face of the backsheet presents the fibrous substrate, e.g., rayon. The dedicated fastening surface typically consists of a strip of thermoplastic film having a high elastic modulus, e.g., polypropylene, as disclosed in EP-B-80 647, or in GB 2,129,689. Preferred herein are dedicated fastening strips of a biodegradable thermoplastic polymer, for example the hydroxy acid copolymers disclosed hereinabove.

Any of the well known configurations and constructions may be used as the adhesive tape 55. For example, the adhesive tape 55 may be a single use tape or a multiple

use tape (i. ., r fastenable). A preferred adhesive tape 55 is a Y-shaped tape as described in detail in U.S. Patent 3,848,594 entitled Tape Fastening System for Disposable Diaper which issued K.B. Buell on November 19, 1974, which patent is incorporated herein by reference. The fastening means 54 are provided at both the first and second longitudinal sides, 26 and 28 respectively.

The preferred adhesive tape 55 illustrated in Figure 2 has a proximal end 56 and a distal end 58. The proximal end 56 is that end of the adhesive tape 55 which the proximal of the diaper 10 affixes to the diaper 10 while the distal end 58 is that end of the adhesive tape 55 which the user affixes to the diaper10 when fitting the diaper 10 to the wearer. The proximal end 56 is affixed to the first waist portion 42 and after fitting the diaper 10 about the waist of the wearer the distal end 58 is affixed to the second waist portion 44 thereby causing the diaper 10 to encircle the waist of the wearer and effecting a waist closure.

As disclosed hereinabove, the second waist portion 44 is preferably provided with a strip of material having optimum properties for repeated fastening of the adhesive tapes. The second waist portion 44 may have indicia 80.82 facilitating proper fitting of the diaper.

The preferred embodiments disclosed herein are not intended to limit the scope of this invention. The scope of the invention, including but not limited to the preferred embodiments described herein, is defined by the following claims,

Claims

1. A biodegradable, liquid-impervious, sheet laminate, suitable for use in disposable absorbent products, comprising :

a) at least one liquid-impervious film of a biodegradable thermoplastic polymer; and

b) at least one layer of a fibrous substrate comprised of biodegradable fibers.

2. A biodegradable sheet laminate according to claim 1, wherein the fibrous substrate has a tensile strength, at break, in cross-machine direction of at least 4 N.

3. A biodegradable sheet laminate according to claim 1 or 2, wherein the biodegradable thermoplastic polymer is a copolymer having a weight average molecular weight above 10.000 and containing repeat units

$$O.CH(CH_3)CH_2CO \qquad I$$

and repeat units

$$O.CR^1R^2(CR^3R^4)_nCO \qquad II$$

where n is 0 or an integer and R^1, R^2, R^3, and R^4 are each selected from hydrocarbon radicals; halo- and hydroxy-substituted hydrocarbon radicals; hydroxy radicals; halogen atoms; and hydrogen atoms, provided that, where n is 1 and R^2, R^3, and R^4 are each hydrogen atoms, R^1 is not methyl, said repeat units II constituting 0.1 to 50 mole % of the total repeat units in said copolymer.

4. A biodegradable sheet laminate according to claim 3, the thermoplastic polymer being characterized in that R^2, R^3 and R^4 are each hydrogen.

5. A biodegradable sheet laminate according to claim 1 or 2, wherein the biodegradable thermoplastic polymer is a copolymer having a weight average molecular weight above 10.000 and containing at least 50 mol % of repeat units

$$O.CH(CH_3)CH_2CO$$

and being characterised by a triplet at 4.3 ppm as measured by proton nuclear magnetic resonance spectroscopy and peaks at 59.89 and 33.83 ppm (relative to a tetramethyl silane standard) measured by ^{13}C nuclear magnetic resonance spectroscopy.

6. A biodegradable sheet laminate according to any one of claims 3-5, characterized in that the biodegradable thermoplastic polymer has a weight average molecular weight of at least 200.000.

7. A biodegradable sheet laminate according to any one of claims 1-6 characterized in that the fibrous substrate is a non-woven rayon fabric having a basis weight of at least 15 g/m^2.

8. A biodegradable sheet laminate according to claim 7 wherein the nonwoven rayon fabric has a basis weight of from 19 to 40 g/m^2.

9. A biodegradable sheet laminate according to any one of the preceding claims wherein the biodegradable thermoplastic polymer film has a thickness of from 15 to 30 micrometers (12.5 to 37 g/m^2).

10. A disposable absorbent product comprising

a) a liquid pervious topsheet;

b) a liquid-impervious backsheet; and

c) an absorbent structure disposed between said topsheet and said backsheet; characterized in that said liquid-impervious backsheet is a biodegradable sheet laminate according to any one of claims 1-9.

11. The disposable absorbent product of claim 10 which is a disposable diaper.

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